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Education in human factors and systems safety has been incorporated into aviation degree programs at university level for many years. However, there has been little research to measure empirically the impact that this education has had on safety outcomes in the field when the students have completed their degrees. A study is presently being conducted involving graduates from the University of NSW at the Australian Defence Force Academy in Australia who had obtained the degree of Bachelor of Technology in Aviation. Following their graduation, these students had been posted to various flying squadrons within the Australian Defence Force in an operational capacity. Research methods included attitude and knowledge surveys, as well as a statistical and qualitative comparison of academic results and military flying training performance with a control group of other pilots who had not completed this education or had joined the Australian Defence Force in a direct entry capacity. The preliminary results are very encouraging.

Many universities offering a bachelors program in aviation have incorporated the study of human factors and systems safety into their degree. Although pilots are regularly tested in terms of piloting skills and emergency responses it has been more challenging to determine if education and training courses in human factors and system safety have had an impact on the performance of pilots when they become operationally active. Measures of attitudes towards education and training are frequently taken immediately after courses are delivered and whilst student satisfaction is an important component of learning, these measures do not provide evidence of the application of this knowledge in a working environment. In order to tap into how these courses have affected individuals a more comprehensive approach to evaluation is needed.

Kirkpatrick and Kirkpatrick (2006) first developed the 'four level model' of training program evaluation in 1959 and it is used widely in the education and industrial sectors. The model focuses on evaluating student's *reaction*, *learning*, *behaviour* and *results*. A meta-analysis of the relations among training criteria (Alliger, Tannenbaum, Bennett, Traver & Shortland, 1997) found that student reactions could be further augmented into *affective reactions* and *utility judgements*. The latter refers to job relevance, that is, can the trainee provide evidence as to how the training has influenced the way they now approach or perform their work? The measure of *Learning* can also be further broken down into *immediate knowledge* and *knowledge retention*. *Behaviour* refers to on the job performance, that is, has the education and training transferred from the classroom to the workplace, for it is application to the job that, in most cases, defines training success (Allinger et al, 1997). *Results* are defined by organisational impact, for example, productivity gains, customer satisfaction, and could be extended to employee morale. In operational aviation it has been difficult to determine the impact that human factors and system safety education and training has had on pilots because either comprehensive testing was

considered to be too difficult or those organisations who have comprehensively evaluated their personnel have not made the results public.

In 2001 a new undergraduate degree program was offered to military officer cadets who had successfully completed 15 hours of flight screening and were selected to undergo training as pilots within the Australian Defence Force (ADF). This degree, the Bachelor of Technology in Aviation (BTech(Avn)) is based on aeronautical engineering together with compulsory, core educational courses in aviation human factors and system safety. Additionally, the students complete a major research project and many choose to conduct experimental research into a human factors related topic. The officer cadets enrolled in this degree spend 26 months at the University of New South Wales at the Australian Defence Force Academy (UNSW@ADFA) concurrently undergoing officer training and then go on to complete the flying training component of their degree prior to graduation (Harrap, Burdekin & Lewis, 2007). Upon graduation they are assigned, according to their operational aptitudes and abilities, to various flying squadrons from airlift to fast jet capabilities where they work alongside pilots who may not have received any education or training in human factors and system safety or who may have had minimal exposure to these concepts.

The aim of the present study was two fold. Firstly to evaluate the BTech(Avn) program and secondly to determine the impact that human factors and system safety education has had on graduate pilots within the ADF flying squadrons.

Method

Participants

Postgraduate students from the UNSW@ADFA BTech(Avn) degree and the ADF Advanced Flying Training School were invited to partake in the study. These graduates are now actively flying in a variety of operational squadrons within the ADF including fast jets, heavy lift transport, maritime and rotary wing platforms. An equal amount of ADF pilots currently flying in the same operational squadrons but, who have not completed the BTech(Avn) degree were also invited to participate and these pilots acted as a control group.

Design

The study was guided by the Kirkpatrick (2006) approach to education and training evaluation and further broken down to compare results by temporal distance. Four levels of review were designed into the evaluation materials – *reaction, learning, behaviour and results* with reaction and learning containing two further levels of distinction – affective reactions and utility judgements; and immediate knowledge and knowledge retention. To measure affective reactions towards the human factors and system safety education, participants were asked to complete a survey entitled the Course Experience Questionnaire (CEQ) which is used in Australia to link institutional performance with Government funding. The CEQ is designed to measure student satisfaction with a degree program post graduation. In this study these results would be compared with the average satisfaction levels that students expressed immediately after completing courses in human factors and system safety subjects. To measure utility judgements

participants were asked to complete the Flight Management Attitude Questionnaire (FMAQ), which is widely used by civil aviation organisations and the ADF to measure safety culture; and, a questionnaire which gave participants the opportunity to specifically rate their satisfaction with, and comment on, specific aspects of the BTech(Avn) program.

A knowledge audit was designed to assess how much human factors and system safety knowledge was retained by the participant and how he/she applied this knowledge in the workplace. These results would be compared to the average results achieved for these questions whilst the experimental participants were still at university. In order to evaluate behaviour, the flying supervisors of both the BTech(Avn) graduates and the control group of pilots were asked to comment on the behaviour and performance of the participants using a modified NOTECHS assessment. To measure results the author obtained information relating to any commendations, prizes or awards that the participants had received and questioned the flying supervisors concerning the participant's performance and contribution to the squadron.

Procedure

The study was divided into two stages. Stage one involved the evaluation of the BTech(Avn) program and two questionnaires – the CEQ and the BTech(Avn) Evaluation Survey – were distributed to the BTech(Avn) graduate participants only. To ensure anonymity and to encourage critical evaluation an independent Internet survey company was used.

Stage two of the study was mainly concerned with determining the impact that human factors and system safety education has had on pilots and involved the researcher visiting the ADF squadrons where former BTech(Avn) students are now based. The participating graduates and the control participants were asked to complete a knowledge audit which tested their awareness of human factors and system safety information. Furthermore, the questions asked participants to describe how they would apply or expect these concepts to be applied in their workplace. Both groups were then asked to complete the FMAQ. No names were requested on either document and the only distinguishing feature was the separation of experimental and control groups responses.

The operational flying supervisors of these graduates and control pilots were asked to report their workplace assessment of the participants using the modified NOTECHS questionnaire. Data was also gathered on any prizes and awards that participants had obtained during their short careers as military pilots.

Results

The results so far have been very encouraging. To date 69% of BTech(Avn)graduates have submitted returns for stage one of the study. The researcher is expecting this response to increase, as several graduates are currently serving overseas and have indicated they were unable to respond due to the present operational tempo. Table 1 shows the evaluation rating of the BTech(Avn) degree program.

Table 1. *Course Experience Questionnaire Summary*

Please select a rating based on our satisfaction with the Bachelor of Technology in Aviation program						
	Strongly disagree				Strongly Agree	Rating Average
The staff put a lot of time into commenting on my work	0.0%	3.8%	30.8%	53.8%	11.5%	3.73
The teaching staff normally gave me helpful feedback on how I was going	0.0%	0.0%	26.9%	62.9%	3.8%	3.77
The program helped me develop my ability to work as a team member	0.0%	7.7%	38.5%	50.0%	3.8%	3.50
The teaching staff of this program motivated me to do my best work	0.0%	11.5%	38.5%	50.0%	0.0%	3.38
The program sharpened my analytical skills	0.0%	3.8%	19..2%	57.7%	19..2%	3.92
My lecturers were extremely good at explaining things	0.0%	4.0%	20.0%	64.0%	12.0%	3.84
The teaching staff worked hard to make their subjects interesting	0.0%	0.0%	15.4%	57.7%	26.9%	4.12
The program developed my problem-solving skills	0.0%	11.5%	26.9%	57.7%	3.8%	3.54
The staff made a real effort to understand difficulties I might be having with my work	0.0%	3.8%	42.3%	50.0%	3.8%	3.54
The program improved my skills in written communication	0.0%	11.5%	19.2%	61.5%	7.7%	3.65
As a result of my program, I feel confident about tackling unfamiliar problems	0.0%	7.7%	50.0%	34.6%	7.7%	3.42
My program helped me to develop the ability to plan my own work	0.0%	3.8%	30.8%	57.7%	7.7%	3.68
Overall, I was satisfied with the quality of this program	0.0%	0.0%	15.4%	61.5%	23.1%	4.08

When given the opportunity to elaborate on various aspects of the human factors and systems safety educational subjects they had studied during their degree respondents gave insightful answers, a summary of which follows:

Figure 1. *Question: Can you nominate a particular lecture or piece of human factors or system safety information that has influenced or impacted upon your work or flying and describe how?*

"I've had situations where I've recognised the "holes in the cheese" line up, and subsequently raised concerns, all due to what I learnt in this degree."

"The courses allowed you to be aware of safety and human factors issues so that you may realise a potential problem that you may not have otherwise realised was developing."

"The understanding of the impact of fatigue has been particularly relevant for me. It is a constant factor and understanding that it has an insidious nature has helped me make decisions to not fly when it has been appropriate to do so. I also think that having a good understanding of the Reason Model has made me more aware of potential risks and allowed me to take appropriate action."

"The fact that the culture of an organisation can have such a large impact on aviation safety and is generally the root course of problems is something I think about often. I still look out for systemic problems in my work place regarding procedures and products."

"I remember being taught about visual illusions at night, in particular, the "mothball effect" - how some pilots don't flare because they fixate on the lights on the runway. I had a similar situation where I just stared at the runway, and struggled to keep the aircraft lined up on finals on a particularly dark night (all we could see were the lights). I remembered what I was taught, and went against what "felt" natural, and didn't overcorrect the aircraft. I then told myself not to fixate on the runway and we had a safe landing."

"Despite a massive push on safety from all levels, aviation safety is rarely a perfect system with many problems observed at many levels. The big safety focus from the courses gives me the confidence and ammunition to argue against particular procedures, problems etc."

Another view from a participant indicates that he/she may not have yet realised that safety is an individual responsibility.

Figure 2. *An alternative opinion*

"[The courses] are useful for a bigger picture view of aviation safety but at the junior level have not been particularly applicable. The higher level aviation safety decisions are generally made without input from members as junior as myself. However I think the training will be useful in the future when graduates of our program are more able to influence decisions made in regards to aviation safety."

Discussion

Stage one of the study has thus far provided some extremely useful data. The satisfaction – affective reaction - rating averages for every question asked on both the program CEQ and the human factors and system safety course questionnaire have been in the upper quartile. These results compare favourably to other university programs. However, the answers to the open response questions provide a more comprehensive indication of how the information studied during these courses has impacted upon the careers of the pilot graduates – utility judgements. The comments that were highlighted in this preliminary report include: sound knowledge of the organisational incident and accident; the insidious nature of fatigue; organisational and safety culture issues; and, human information processing and limitations. It is particularly rewarding to hear that at least one graduate believes he/she is sufficiently educated in the subject of aviation safety to feel confident enough to argue a safety issue with a superior officer in a military environment.

Stage one data collection is on-going due to many potential participants currently serving in humanitarian efforts, border protection duties and war zones overseas. Stage two involves visits to military bases around Australia in order to brief pilots and supervisors, and administer surveys. This process is complete and the data are currently being analysed.

Expected Outcomes

It is anticipated that there will be several outcomes from this research. Firstly, the results will indicate the level of transfer of education and training from the classroom to the cockpit and this result will impact upon and shape the future development of content and method of delivery for the UNSW@ADFA BTech(Avn) program. Secondly, the study will compare the attitudes, knowledge, behaviour and results of pilots who have received education and training in aviation

human factors and systems safety with those of a control group of ADF pilots who have not. The data from this study will indicate whether human factors and system safety education and training has assisted in developing in ADF pilots a healthy attitude towards and understanding of safety issues, and a greater appreciation and application of safety concepts and knowledge in their flying skills and workplace performance. Evidence of the development of these attributes would help to attract support for future education and training in this field.

References

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